New tools for X-ray astrophysics in the epoch of interoperability

Ivan Zolotukhin (IRAP / Moscow U) Igor Chilingarian (CfA / Moscow U)

Talk outline

- Who we are
- XMM-Newton catalog and motivation
- Website: what batteries inside?
- New development model (citizen science)
- Demo & science cases
- Conclusions

Ivan Zolotukhin

- 2003–2009: large social networks, PostgreSQL consulting, independent consulting to Top10 Internet companies
- 2009: PhD in astrophysics, Moscow State U
- 2010–2012: Paris Observatory
- 2012-now: IRAP, Toulouse, France

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Igor Chilingarian

- Past: postdoc in Paris and CDS
- 2011-now: staff at the CfA

- First VO publication in Science magazine
- Second VO publication in Science magazine

Who we are

- 2 ADASS tutorials (2010, 2012)
- Last one: pure VO online discovery of the loneliest galaxies in the Universe





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Isolated compact elliptical galaxies: Stellar systems that ran away

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XMM-Newton catalog

- XMM-Newton is X-ray observatory by ESA launched in Dec 1999
- Large FOV: ~70 sources / pointing (very prospective for serendipitous science)
- 3XMM-DR5 (arXiv:1504.07051) is the largest X-ray source catalog ever created: 2.5% of the sky, 560k detections, 400k sources (credit: XMM Science Survey Center)





Identifying strange AGNs using multiwavelength data

lgor

Motivation for the new catalog app

- I was main responsible for the 3XMM-DR5 catalog compilation
- Old XMM-Newton catalog webpages: expensive to take over
- Wealth of high level science products by the community (XMM SSC) but without convenient access
- Time cost comparable to reimplementing improved version from scratch
- Unlimited source of a manpower as an experiment: why not trying it?

LEDAS: ARNIE services				Leicester Database and Archive Service
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XMM-Newton catalog before

	XMM-NEWTON SURVEY	SCIENCE CENTRE	
	Search Query can be XMM-Newton catalog objects Search query can be XMM-Newton catalog column name and co AND/OR with another constraint. Column name can be: SC_RA,	SEARCH Instraint on its value glued by SC_DEC, SC_POSERR,	
	Example: cone('M31', '1deg') and so, det, mi > 8	Show query language	
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NEWS		SSC OVERVIEW	
22	28th XMM-Newton SSC consortium meeting to be held 22-23 January 2015 at MSSL.	Launched in 1999, the XMM-Newton satellite is the major European X-ray observatory-class telescope, carrying also a co-aligned UV/optical monitor telescope, that is operated by the European Space Agency (ESA). The XMM-Newton Survey Science Centre (SSC) has responsibilities within the XMM-Newton project in four main areas:	
Nov 2014	London, UK	that is operated by the European Space Agency (ESA). The XMM-Newton Survey Science Centre (SSC) has responsibilities within the XMM-Newton project in four main areas:	

XMM-Newton catalog after



Reincarnation of the world reference exoplanet database, http://exoplanet.eu



Feb. 19, 2014 ESA selects the Plato mission to hunt planets by transits

update : Jan. 12, 2014

Technology stack

RDMBS: PostgreSQL

Application language: Python

Web framework: Django





SAMP in a browser



AstroTools library: http://goo.gl/zyF0id

X-ray spectral fitting

 Web implementation of a complex thing: source, background, RMF, ARF

Wrapper over Sherpa

Powered by Xspec



Query language

Boolean expressions instead of endless forms (think Google) + SIMBAD resolver

Query examples

- M82 select sources in 10 arcmin vicinity of M82 center
- cone('M31', '1deg') AND sc_det_ml < 100 select faint X-ray sources not
- is_ulx = true AND n_detections > 2 select ULXs which were detected r
- iauname IN {"3XMM J053406.7+220337", "3XMM J053406.6+220438"} select
- srcid IN {3, 4} select specific sources by their source IDs (useful for la

All-time XMM-Newton photon database

- 100 billion photons that's all photons ever registered by the XMM-Newton for 15 years
- JS9 to access combined images
- Events extraction and barycentering
- Bringing (python) codes to the data

More batteries

- Web sessions (personalization)
- Name resolver
- JavaScript diagrams (jQuery, Angular)
- Aladin Lite by CDS
- ∎ JS9
- Java WebStart of Aladin and TOPCAT





GULAR**js**

New development model

- High-level full-time employed IT engineers a.k.a.
 volunteers
- Coordination through Bitbucket (git)
- New type of citizen science? Unlimited source of free manpower?

New development model

- Project duration: ~1.5 yr
- My time: 5% FTE
- Volunteers time: up to 3 months FTE
- This team is so far unique, but there are much more citizen science enthusiasts!

Andrew Zolotov, CEO at UserHouse, Moscow – *artwork*



Alexey Sergeev,

deputy VP at Mail.RU, Moscow – *design, artwork*



Askar Timirgazin,

programmer at Ontico, St Petersburg – *front-end, JavaScript*



Maxim Chernyshov,

programmer at ?, Vladivostok – *back-end, Python*



Science cases

- Low-luminosity AGN
- New cataclysmic variables
- Discovery of the 1st non-recycled pulsar (pulsar factory)
- Discovery of a cooling neutron star
- Tidal disruption events
- Hyper-luminous X-ray sources

Demo at http://xmm-catalog.irap.omp.eu

(to see why researchers are excited and make 100 clicks 2-hrs long sessions)



2nd known cooling neutron star

Tidal Disruption Events





Unusual X-ray pulsar Too slow rotation for such intensive accretion



Credits

- Observatoire Virtuel Grand-Sud Ouest (OV-GSO data centre) travel funds
- N. Webb (PM of the XMM SSC) hardware
- M. Bachetti, N. Sartore research collaboration

Future

- Wealth of research to be published
- Tens of new pulsars in these data

- eRosita all-sky X-ray catalog
- Chandra? Swift?
- ...but the author is on the verge of leaving astronomy

New archive model

- Source catalog = table of contents of the archive
- Full featured transparent access to low-level data thanks to interoperable data and software
- All-time (initially heterogeneous) observations are seen as a single event list
- Bringing code to the data (yet manually)

Message to take away

- http://xmm-catalog.irap.omp.eu is a new archive model where prominent discoveries can be made online
- X-ray data (photon lists, source/background spectra, RMFs, ARFs, timeseries) and tools (Sherpa, JS9, Aladin Lite, TOPCAT) form powerful analysis environment and finally help reach research synergy
- Tiny motivated team of IT professionals (a.k.a. citizen scientists) can create extraordinary projects